bulk solids handling Volume 2, Number 4, December 1982

# Staten Island Coal Export Terminal

**Leslie P. Orr and Terry L. Thompson, USA**

## Summary

The authors review the future prospects for the export of steam coal from the USA and the available port facilities on the East Coast to deal with this. The background to the decision to build a major new coal export terminal on Staten Island is detailed. The plans for the terminal, to be completed in 1986, are explained in detail and the factors leading up to systems chosen discussed.

## 1. Introduction

The City of New York is proposing a steam coal export terminal for New York Harbor. The City's Department of Ports and Terminals has devoted nearly two years to the development of a design which will enable this project to come to fruition. We believe the terminal is environmentally acceptable; is consistent with existing land uses; and is economically attractive.

The port is planned for Stapleton, on the northeastern shore of the New York City borough of Staten Island. Steam coal will be transported to the western shore of Staten Island by unit trains, unloaded, and stored in slurry ponds at the Arlington Rail Yard. It will be transported across Staten Island by a coarse coal slurry pipeline. The coal will be dewatered at Stapleton and loaded into colliers at the rate of 4,000 t/h. Water will be returned to Arlington for reuse. The terminal will be able to handle 20 million t of steam coal a year at maximum capacity. It is scheduled to open in 1986.

The need for efficient loading terminals for the export of steam coal has been made clear during the past year. The United States, a major exporter, is not capable of meeting the increase in demand with our existing port system. For the U.S. to continue in its role as a major exporter of steam coal to Europe, we must ensure buyers that shipments can move through our ports on time and at a cost comparable to competing exporters.

Numerous projections of U.S. steam coal exports through 2000 have been published since the first unexpected upswing in the demand for this fuel. The first and most prominent source of projections was the World Coal Study which predicted that world coal consumption would triple by the end of the century. The United States, according to WOCOL, would export 50—115 mill. t of of steam coal by 2000 to Europe [1]. Other more realistic estimates have been considerably lower since publication of WOCOL. Some of the more recent projections estimate that steam coal exports to Europe will double by 1985 to 28 mill. t. According to ICF, U.S. steam coal exports to Europe are expected to reach 48 mill. t in 1990 and 64 mill. t by 1995 [2].

The potential for the United States is great. At this time, however, ports are ineffective because the terminal operations are not designed to handle steam coal; they are designed for metallurgical coal. Metallurgical coal requires many separate storage piles corresponding to the vast number of coal types. Steam coal, on the other hand, needs fewer but larger stockpiles. Steam coal shipped through metallurgical coal terminals is stored in hopper cars, the method normally used for "met" coal. This system ties up capital and causes inefficient storage and unloading operations.

While steam coal trade is increasing, so is the demand for large colliers to carry the commodity. The economies of scale in ocean transportation, achievable by large coal colliers, have spurred this demand. The over-the-water costs, on a per ton and per ton-mile basis, decrease in inverse proportion to the size of the collier. For example, the per ton cost of shipping coal from New York to Fos, France, declines from $ 13/t for a 75,000 DWT collier to approximately $ 8/t for a 150,000 DWT collier and to $ 6.50—$ 7.00/t for a 260,000 DWT collier (1981 costs) [3].

There are a plethora of proposed coal export terminals on the East and Gulf Coasts; however, the ones that will actually be built must meet several criteria:

1) channels deeper than 45 ft at Mean Low Water;
2) low and equitable user fees to fund deepening of these channels;
3) close proximity to the coal supply region;
4) short sailing time to foreign markets;
5) fast tracking of planning and construction;
6) private sector interest in financing and developing the project.

New York is in a position to be a leader in the coal export market.

---

Based on a paper delivered at the Fourth International Symposium on Freight Pipelines, Atlantic City, NJ, October 4—6, 1982 and to be published in the Journal of Pipelines (Elsevier, Amsterdam)

## 2. New York Advantages

New York has several key advantages which make it one of the most attractive sites for a coal export terminal on the East or Gulf Coast:

1) cheapest dredging costs on the East or Gulf Coast;
2) direct access to Eastern coal fields in Pennsylvania, Ohio, West Virginia and Kentucky;
3) shortest sailing time to Europe of any East or Gulf Coast coal port;
4) a commitment by the City of New York to move quickly on development plans so that construction can begin
5) the interest from the private sector to own and operate the terminal.

Taking the criteria mentioned earlier one at a time and comparing the Port of New York to its competing ports we find:

Firstly, New York can dredge its harbor to a lower depth and at a lower cost than any East or Gulf Coast port. The main entrance channel to New York Harbor, the Ambrose Channel, now at 45 ft at MLW, can be deepened to 68 ft for approximately $ 150 mill. The Ambrose Channel is predominantly sand and silt and has an *average* depth of 50 ft. The length of channel that would have to be dredged is approximately 10—12 miles and connects to a two mile stretch of naturally deep water in the Verrazano Narrows. This area has depths close to 100 ft. The incremental increase in maintenance costs for a 68 ft channel is approximately $ 5 mill./year.

In comparison, Baltimore Harbor, now at 42 ft MLW, can be dredged to 50 ft at a cost of approximately $ 420 mill. The New Orleans Ship Channel can be dredged from 40 ft to 55 ft at MLW at a cost of approximately $ 500 mill. Furthermore, New Orleans' incremental maintenance dredging costs are in the $ 175 mill./year range (see Table 1).

Table 1: Proposed Channel Deepening Projects

| | Existing Channel depth (ft) | Proposed Channel depth (ft) | Quantity of dredged material (Mill. $yd^3$) | Cost ($ Mill.) |
|---|---|---|---|---|
| Baltimore | 42 | 50 | 72 | $ 420 |
| Hampton Roads | 45 | 55 | 100 | $ 480 |
| Mobile | 40 | 55 | 142 | $ 392 |
| New Orleans | 40 | 55 | 133 | $ 500 |
| New York (Stapleton) | 45 | 68 | 50 | $ 150 |

Source: Port Authority of New York and New Jersey, 1980; *Journal of Commerce*, October 1981; *Coal Week International*, February 3, 1982; *AAPA Advisory,* Vol. XVI, No. 17, April 26, 1982.

At the time of writing, the Port of Baltimore has been approached by the Reagan Administration on their proposed channel deepening project. The Administration's proposal was for 25% Federal funding to be paid back over 50 years by Baltimore and 75% local funding. Thus far, Baltimore has not been able to find the capital.

It is believed that the channel in New York Harbor can be funded entirely out of local resources — City, State and Port Authority. The user fees would be minimal, thus allowing maximum over-the-water savings.

Several European import ports are using or are planning to use deep water vessels (ships over 100,000 DWT) and some, like Rotterdam, can handle ships up to 250,000 DWT (see Tables 2 and 3). These vessels require channels of 50 ft to 68 ft. *The ports capable of loading such vessels are in countries other than the United States* — such as South Africa and Australia (see Table 4 and 5). These foreign ports can export coal to several European ports including the Netherlands, Spain, Denmark, Belgium and France. A deepwater port such as that planned for New York, will enable the United States to compete in this market (see Table 1).

Secondly, the Staten Island facility has access to the Appalachia coal fields via Conrail, the CSX System and the Norfolk Southern. Although the future of Conrail is not guaranteed, its recent performance has been quite good. It has made money in several successive quarters — during a major recession. It has begun the long process of overhauling its equipment and track, shedding excess and under-utilized track, and Congress has allowed it to reduce its labor costs. The tracks leading out of the coal fields to New York have been completely rebuilt and are capable of handling unit trains. Although New York is slightly further away from the Kentucky and West Virginia area coal fields than Baltimore, New York's ability to accommodate unit trains can result in comparable rail rates. New York can also provide Conrail with an efficient export terminal with deep water that it does not currently have on the East Coast. The CSX System has direct access to Staten Island using the Conrail system and provides New York potentially with access to all grades of coal used in the export trade. Moreover, Norfolk Southern has access to New York and is a potential supplier of coal.

Thirdly, New York also has the shortest sailing time to Europe compared to any other East or Gulf Coast coal port. For example, New York to Fos, France is $^1/_2$ day shorter than from Hampton Roads. It is 2—5 days closer than ports from Baltimore to New Orleans (see Table 4). Given the cost of operating large colliers, a saving of several days' sailing time in each direction can have a measurable impact on the price of coal. Furthermore, shorter sailing times allow vessel operations more revenue trips per year, thus increasing profits and reducing the number of ships needed for a given annual tonnage.

Fourthly, the City of New York has committed itself to fast tracking of the coal terminal in Staten Island. Mayor Edward Koch has made the dredging of New York Harbor and the development of the coal slurry terminal his highest priority in the field of economic development. The City has devoted the staff and resources to this project to encourage construction in the shortest time frame possible.

Fifthly, the City has insisted upon private financing of the coal terminal. This guarantees that the risk is borne by the private sector — as it should be; construction moves expeditiously because of the profit incentive and the City can use its own capital resources to contribute to the dredging of New York Harbor.

Another point concerning the potential of New York as a coal port is that the terminal can be designed for efficient handling and economic attractiveness. The Arlington Rail Yards can accommodate unit trains which will result in lower freight rates and quick turnaround. Other East and Gulf Coast ports cannot take advantage of unit train rates. Only single car rates and train load rates, both higher, are quoted for these ports. Combining this with the present channel depth of 45 ft and the proposed channel depth of 68 ft can mean that New York will become the most economical port from which to export coal.

The Port of New York's superb physical and economic advantages led the City of New York Department of Ports and Terminals to examine the practicality of siting a major coal export terminal on the northeastern shore of Staten Island. The Northeastern shore, in particular the Stapleton-Tompkinsville-Clifton area, is adjacent to the naturally deep water of the Verrazano Narrows, thus providing the City with the optimum location within New York Harbor for a coal terminal.

Table 2: New Developments Coal Loading Terminals Including Upgrading Existing Ports Tonnage over 100,000 DWT

| Country | Definite | Proposed | Size (DWT) | Draft (in ft) | Year |
|---|---|---|---|---|---|
| Australia | Hay Point (2nd Loader) | | 175/200,000 | 62 | 1983 |
| | Newcastle (Upgrading) | | 125,000 | 49 | 1983 |
| | Newcastle (Kooragang) | | 150/175,000 | 50—56 | 1984/5 |
| | Pt. Kembla (New Loader) | | 150,000 | 54 | 1983 |
| | Gladstone (Clinton) | | 120/150,000 | 50—54 | 1982 |
| | Abbot Point (New Loader) | | 120/150,000 | 54 | 1984/5 |
| | | Brisbane Fishermans Island | 120,000 | 50 | 1987/8 |
| Canada | Roberts Bank (2nd Loader) | | 200,000 | 62 | 1983 |
| | Prince Rupert (New Loader) | | 200,000 | 62—69 | 1984 |
| | | Gros Cacouna | 300,000 | | 1985/90 |
| | | Point Noire | 300,000 | | late 1980's |
| Colombia | | La Guajira | 130,000 | | 1985/6 |
| South Africa | Richards Bay (Upgrading) | | 200,000 | 62 | 1985/6 |
| China | | Shijiu Suo | 100,000 | | |

Source: Simpson Spence and Young; *"Development of Ports and Ship Sizes in the Coal Trade"*; Paper Presented at "Coal Summit 1981"; New York, June 1981.'

Table 3: Existing Ocean Discharging Terminals Capable of Handling Vessels of Over 100,000 DWT

| Country | Port | Maximum Size Vessel (DWT) | Draft (in ft) |
|---|---|---|---|
| Belgium | Antwerp | 125,000 | 45 |
| Denmark | Ensted/Aabenraa | 140,000 | 49 |
| | Stignaes | 125,000 | 50 |
| France | Dunkirk | 125,000 | 47 |
| | Le Havre | 150,000 | 56 |
| | Fos | 160,000 | 59 |
| Germany | Hansaport | 90,000 | 42 |
| | Wilhelmshaven | 110,000 | 47 |
| Holland | Amsterdam | 150,000 | 45 |
| | Rotterdam | 250,000 | 68 |
| | Ijmuiden | 150,000 | 45 |
| Israel | Hadera | 120,000—160,000 | |
| Spain | Gijon | 150,000 | 45 |
| United Kingdom | Hunterston | 350,000 | 90 |
| | Immingham | 165,000 | 46 |
| | Port Talbot | 125,000 | 49 |
| | Redcar | 160,000 | 56 |

Source: Simpson Spence and Young; *"Development of Ports and Ship Sizes in the Coal Trade"*; Paper Presented at "Coal Summit 1981"; New York, June 1981.
International Bulk Journal, Various Issues.
Journal of Commerce, February 22, 1982.

Table 4: New Developments Coal Discharging Terminals Including upgrading Existing Ports Tonnage over 100,000 DWT

| Country | Definite | Proposed | Maximum Size Vessel (DWT) | Draft (in ft) | Year |
|---|---|---|---|---|---|
| Belgium | Antwerp (Upgrading) | | 150/170,000 | | 1985/6 |
| | | Zeebrugge (New) | 125,000 | 48—50 | 1983 |
| Denmark | Ensted/Aabenraa (Upgrading) | | 170,000 | 56—59 | 1983 |
| | Stignaes (Upgrading) | | 170,000 | 56—59 | 1983 |
| France | Dunkirk (New) | | 200,000 | 69 | 1983 |
| | Le Havre (New) | | 170/200,000 | 56—66 | 1982/5 |
| | Fos (New) | | 250,000 | 66 | 1984/5 |
| | Montoir (New) | | 140,000 | | 1983 |
| Germany | Hansaport | | 120,000 | | |
| | Wilhelmshaven | | 250,000 | | |
| Holland | Maasvlakte (MCT New) | | 250,000 | 68 | 1983/4 |
| | Ijmuiden "Norcot" (New) | | 180,000 | 56—59 | 1985 |
| Italy | Trieste | | 150,000 | | |
| Israel | Hadera (New) | | 170,000 | 69 | 1982/3 |

Source: Simpson Spence and Young; *"Development of Ports and Ship Sizes in the Coal Trade":* Paper Presented at "Coal Summit 1981"; New York, June 1981.
International Bulk Journal, various issues in 1981 and 1982.
Journal of Commerce, February 22, 1982.

Table 5: Existing Ocean Loading Terminals Capable of Handling Vessels of Over 100,000 DWT

| Country | Port | Maximum Size Vessel (DWT) | Draft (in ft) |
|---|---|---|---|
| Australia | Hay Point | 150,000 | 58 |
| Canada | Roberts Bank* | 160,000 | 59 |
| | Neptune Terminal* | 125,000 | 48 |
| | Quebec | 200,000 | 48 |
| Poland | Gdansk | 110,000 | 49 |
| South Africa | Richards Bay | 160,000 | 56 |
| USA | Hampton Roads** | 80,000 | 46 |
| USSR | Vostochny | 125,000 | 49—54 |

Source: Simpson Spence and Young; *"Development of Ports and Ship Sizes in the Coal Trade";* Paper Presented at "Coal Summit 1981"; New York, June 1981.
U.S. Department of Energy, Interagency Coal Export Task Force; *"Interim Report of the Interagency Coal Export Task Force";* January 1981, page 86.

* These terminals are on the west coast of Canada and are not in the export market to Europe.

** Existing channel depths at Hampton Roads currently restricted to vessels about 80,000 DWT when fully loaded, although larger ships, over 100,000 DWT have departed under favorable conditions

## 3. Siting Criteria and Decision Background

The initial "in-house" study by the City's Department of Ports and Terminals focused on several key siting criteria: rail access, site limitations, environmental considerations, capital costs, community reaction and dredging. This initial survey concluded that a *conventional* coal export terminal — one with open ground storage of coal, stacker-reclaimers or underground reclaiming and direct rail access for unit trains — would not be practical for the Stapleton waterfront. The following is a brief description of the Stapleton site and the constraints placed on development there (see Fig. 1).

The City-owned waterfront property at Stapleton-Tompkinsville-Clifton is a mile-long strip on the northeast shore of Staten Island. The 200 acre site consists of approximately fifty acres of upland and close to one hundred-fifty acres of land under water. The site is long and narrow with a maximum width of 2,000 ft. The waterfront to the south consists of commercial and industrial activities, much of it related to shipping, storage and mass transit repair yards. A residential community is several hundred feet to the west. This community continues further to the west and includes several hills which overlook the site. The local residential and business district is undergoing a significant amount of

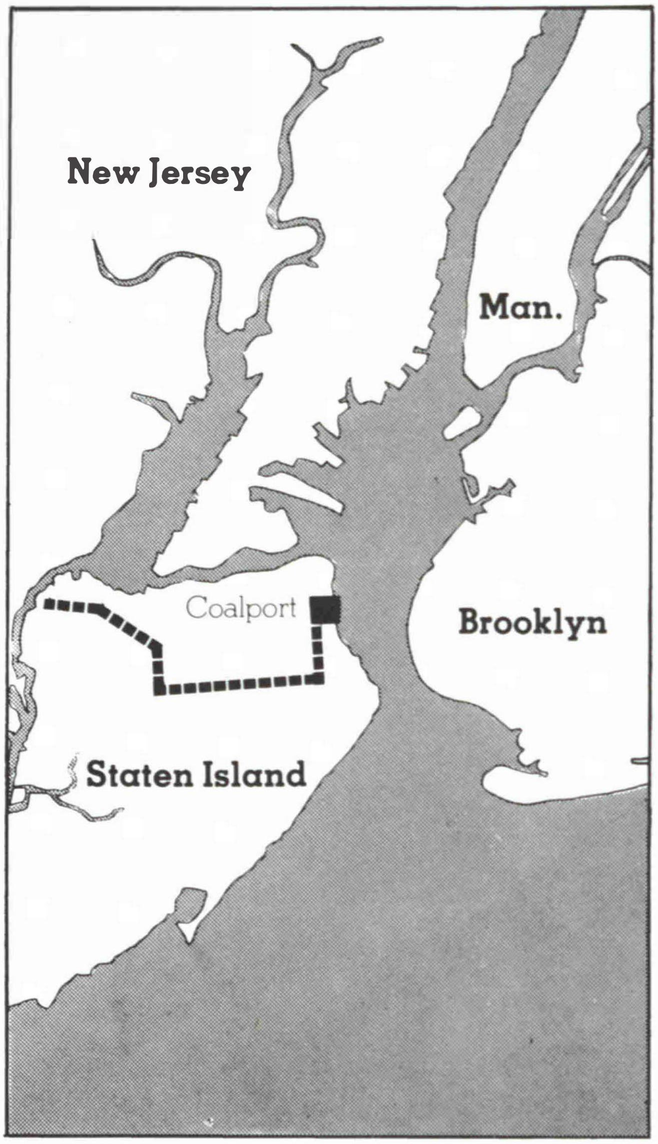


Fig. 1: Map of Staten Island

restoration which the City has encouraged. The community is separated by the Staten Island Rapid Transit tracks, which are elevated along the southern portion of the site, although there are several streets which do lead directly into the waterfront area.

The Stapleton piers have been vacant for over twenty years. Three piers have already been removed because they were hazards to navigation. The entire waterfront area south of Pier 7 through Pier 18 is marked by deterioration. The remaining piers, 8 through 18, are scheduled for demolition in 1983 as part of the U.S. Army Corps of Engineers' New York Harbor Collection and Removal of Drift program. The demolition costs may be as high as $ 20 mill. which will be shared by the City and State of New York and the Army. Although these piers are vacant and deteriorated, they do provide passersby with some of the most breathtaking views of New York Harbor — the Statue of Liberty and Manhattan Island to the north, the Brooklyn shore to the east, and the Verrazano Narrows to the south. The daily activities of the harbor can be seen from the Stapleton waterfront — tugs, barges, tankers, container ships and ferry boats. It is this scenic resource which the community wants to protect and which the Department of Ports and Terminals is committed to protecting. At the same time, the Department also wants to take advantage of Stapleton's other great resource: deep water.

In addition to the constraints of the Stapleton site already mentioned — long and narrow, and the scenic vistas that must be maintained — the other problems presented by this site for a conventional coal terminal were rail access and the sub-surface profile. The rail access into Stapleton would have been along the Staten Island Rapid Transit tracks, a system handling some 137 commuter trains per day. Interruption of this service by unit train operations would have been intolerable. The sub-surface profile indicates that bed rock falls off rapidly all along the Stapleton waterfront, thereby creating enormous capital construction costs for a conventional terminal.

In a study prepared for the Port Authority of New York and New Jersey by the ORBA Corporation, estimated capital costs for constructing a conventional coal terminal at Stapleton exceeded those of a site in New Jersey by some $ 70—$ 140 mill. [4]. Most of these costs are due to the rail access and the sub-surface profile.

In addition, ground storage of coal for a conventional terminal would require approximately 26 acres of the Stapleton waterfront for 1 mill. t of coal in 50 ft high piles. This method of storage would create dust emissions that would require strict controls. The combination of environmental problems not only would be undesirable but could be expected to generate considerable community opposition. High volume open coal storage is not consistent with the scenic vistas this site provides and in addition, sufficient acreage is simply not available.

In summary, the rail access immediately into Stapleton is virtually impossible to rectify for coal unit trains; ground storage of coal is unacceptable at Stapleton; the scenic vistas from Stapleton would be denied to its residents; and the sub-surface profile prohibits construction out into the water for any kind of large structures except at enormous costs.

For all these reasons, the City of New York has rejected the proposal to build a conventional coal terminal along the Stapleton waterfront. Yet, the City has one extraordinary resource that no other East or Gulf Coast port has: access to deep water at minimal cost. The City's answer to taking advantage of this resource is to develop a coarse coal slurry system across Staten Island.

## 4. System Description

The system conceived at Ports and Terminals uses the slurry pipeline as the connecting piece between the rail terminal and the pier. The waterfront facility at Stapleton would consist of a pier, a dewatering building, and possibly enclosed coal "surge" storage, thereby allowing most of the land along the waterfront to be used for public amenities.

### 4.1 Rail Terminal

The rail terminal will be located on the western shore of Staten Island in the Arlington Rail Yards, some 7 miles to the west of Stapleton. The connecting piece would be the country's first coarse coal slurry system in the export trade. The following is a brief explanation of the basic elements of the system.

The rail terminal consists of a 100 acre rail yard in northwestern Staten Island. It is owned by the CSX, or Chessie System, through its B & O division. It is only partially utilized with its primary service bulk shipments to Proctor and Gamble's factory just to the northwest of the Arlington Yards. The Arlington Yards area to the north, west and southwest is primarily industrial: the Howland Hook Container port, Proctor and Gamble, Gulf Oil and the Staten Island Expressway. Just to the north of the rail yard, the City and the Port Authority has initiated construction on a 60 acre foreign trade zone, including three warehouse-distribution buildings and a bus assembly plant. To the northeast, east and southeast, there are residential neighborhoods which have been allowed to encroach upon the rail yard.

This rail yard connects to the Conrail system in New Jersey via CSX and the old Centrail Railroad of New Jersey. CSX has no independent rail access between Philadelphia and its isolated segment on Staten Island. The rail bridge between New Jersey and Staten Island is a single track lift bridge which may require minor modifications to handle unit trains.

The Arlington Rail Yards will function as the unloading area, storage area and slurry preparation area. The parameters that the City has placed on the development of the rail yards are:

1) the yards are to be designed for unit train operations;
2) coal storage will be done in slurry ponds rather than in open ground storage;
3) unloading will be done in an enclosed shed and coal transfer operations to the slurry ponds will also be enclosed;
4) other rail service to Staten Island for Proctor and Gamble and for the Howland Hook Containerport must not be interrupted.

The major constraints in the Arlington area are two-fold: the yards include tidal wetlands and are in proximity to a residential population to the east. It is believed that the City has the basis for claiming the tidal wetlands provided the City undertakes improvement in tidal wetlands acreage elsewhere on Staten Island. The City is attempting to protect the residential community by incorporating unit train operations during daytime hours, by minimizing fugitive dust during unloading and by storing the coal in slurry ponds.

Coal can be dumped from either bottom dump or rotary dump rail cars. The system will allow a 100 car unit train to be completely unloaded within 1 1/2 to three hours depending on the type of cars in the train. Such systems already exist in the United States.

### 4.2 Slurry System

The slurry system contains all the facilities necessary to store, transport by pipeline, and dewater the coarse coal. The 2 inch by zero coal that is delivered by rail to Arlington will be transferred from the four 3,000 t surge silos to storage ponds via rotary-type coal feeders. Water will be added at the feeders, and the coal will be transferred hydraulically. The silos are sized to hold more than a trainload of coal (i. e., 12,000 t). The transfer rate to the ponds will be up to 4,000 t/h, which is the basic system design rate.

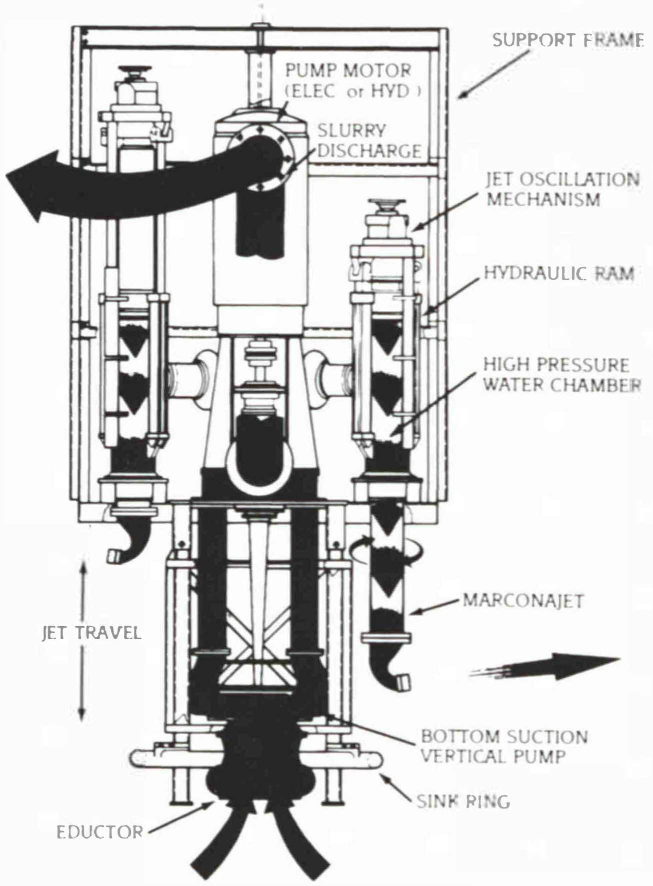
Each storage pond is designed to hold approximately 200,000 t of coarse coal. The original criteria was to have storage equal to 10 % of annual throughput. This would be 10 ponds, or 2 mill. t, at the ultimate throughput of 20 mill. t. A system simulation study, however, showed that, with good management and scheduling, the storage could be held to a maximum of 1.2 mill. t. This is a significant saving and is the recommended system. Six storage ponds would be required: three in Stage I and three in Stage II. In addition, the first three ponds will be compartmentalized into two sections of 100,000 t each, to provide more flexibility for accommodating smaller ships in the early years.

The ponds are 450 ft square by approximately 40 ft deep and will contain saturated coal in the stored mode. Water will be drawn off the bottom of the pond, so that only a foot or two of water is left on top. This will provide the maximum storage volume and provide environmentally benign storage. The reclaim system in the current plan is the hydraulic jet type. The reclaim unit consists, basically, of a large pump and water jets. It is supported and revolves 359° around the pond via a permanent crane-type support structure. The unit will reclaim at 4,000 t/h and at concentrations up to 50 % solids by weight (see Fig. 2). Water can be drawn off as necessary from centrally located sumps, which are piped from filter beds at the bottom of each pond. A water pond, equal in volume to one of the slurry ponds, is installed to store water drawn off during filling and operation.

The operator selects the type of coal to be sent to Stapleton for shiploading. Each pond or section can have a different type of coal. The coal slurry from the selected pond is pumped hydraulically via the reclaim unit to the suction of the Arlington pump station, located adjacent to the ponds. The pump station is a lock-hopper type. This system operates by alternately filling and emptying separate "legs", or chambers, in the pump, using a programmed valving sequence (see Fig. 3). Slurry is displaced from the chambers by high pressure water provided by a centrifugal water pump. The advantage of the system is that the coal itself does not pass through centrifugal pumps, which would grind or attrite the material. Minimization of fines generation was a key criterion in selection of all the equipment in the system. Discharge pressure is approximately 760 psi.

The coarse coal will be pumped to Stapleton through a 7 mile, 32 inch O.D., flanged, grade X-60 pipeline. The pipeline is designed for 4,000 t/h at 45 % solids. The pipeline is buried at approximately three ft. It is located in the median strip of the Staten Island Expressway for about five miles, with most of the rest of the line located in the Staten Island Rapid Transit System (SIRT) right-of-way. The pipeline will be lined with approximately 1 inch of polyurethane for abrasion protection. Attrition of the particles will take place in the pipeline (as well as in the upstream and down stream facilities) and was considered in the design.

At Stapleton, the slurry enters the dewatering plant, where water is removed to a surface moisture level of about 10 %. In addition, the coal is assumed to have an inherent moisture of 4 %. The dewatering plant capacity is 4,000 t/h. The dewatering circuit is similar to that contained in many coal preparation plants. It contains screens, Vor-sivs, and oscillating centrifuges in the primary, or coarse circuit. In the secondary, or fine circuit, it contains



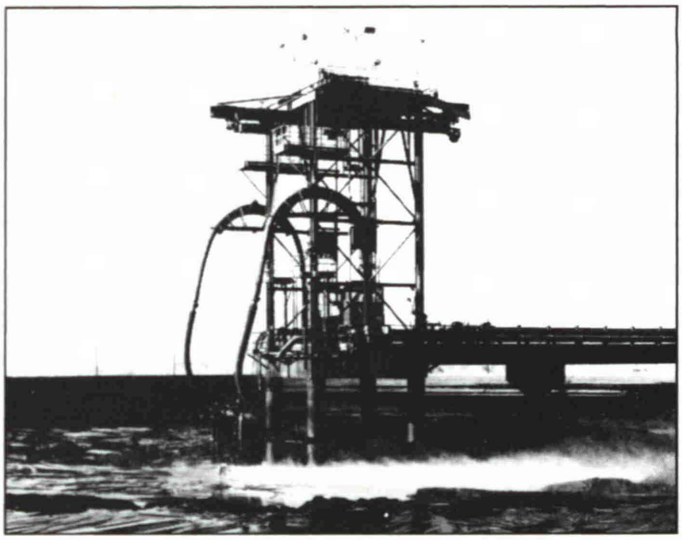


Fig. 2: Typical slurry reclaim unit

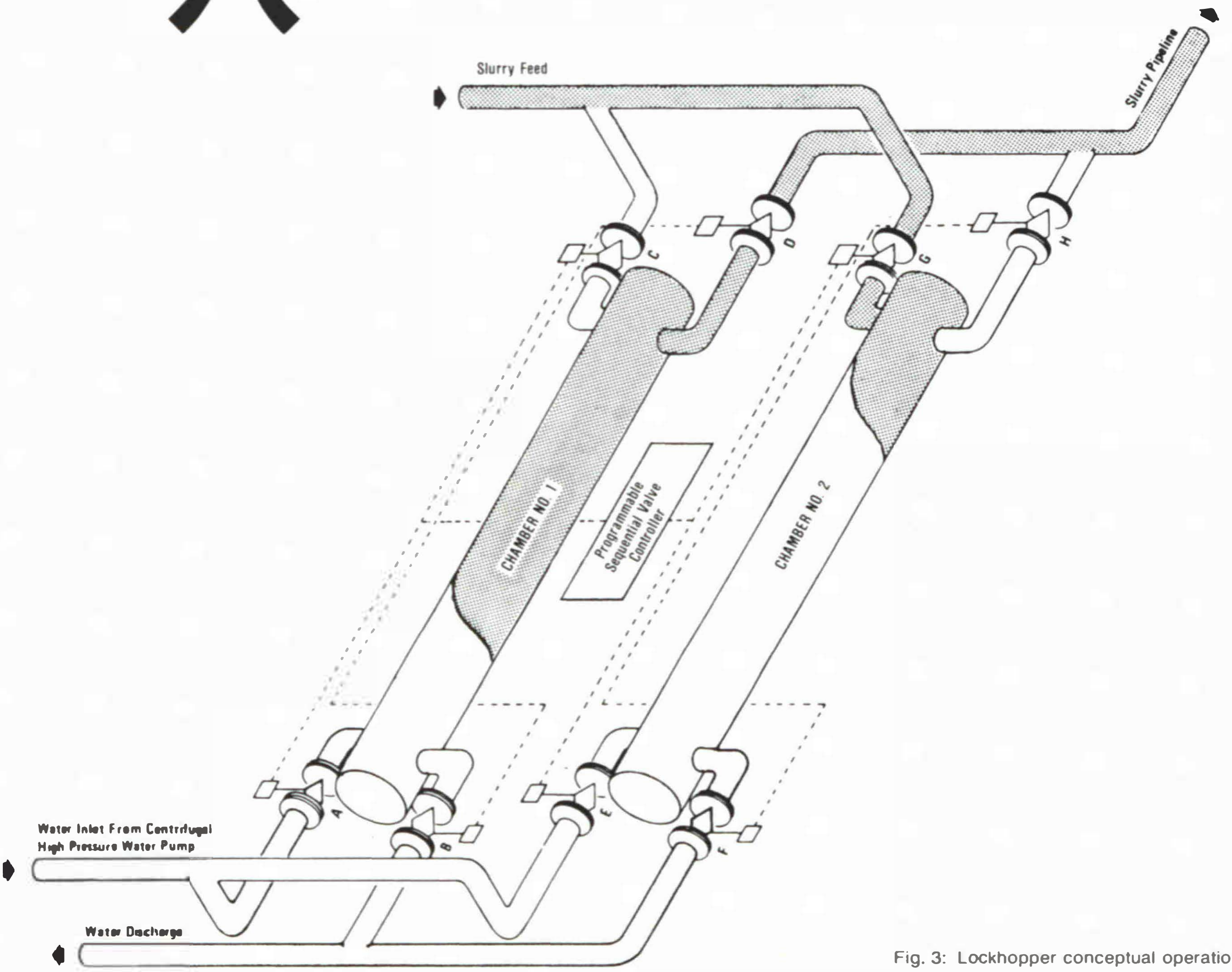


Fig. 3: Lockhopper conceptual operation

hydrocyclones, screen bowl centrifuges, clarifiers, and filter presses. Only about 500 t/h is expected to go through the fine circuit of the dewatering plant. All of the dewatering facilities are contained in a 320 ft by 200 ft by 90 ft high building. Coal at 10% surface moisture exits the building via covered conveyor and is either directly loaded onto ships or diverted to one of the four 4,000 t surge silos.

Water removed from the coal is pumped back to Arlington through a 30 inch diameter water return line. This line is buried adjacent to the coarse coal slurry pipeline in the Staten Island Expressway median and the SIRT right-of way. The line will be internally coated for corrosion protection. In the event that leachates build up in the water, it will be possible to pump the water from Arlington to the Richmond Sewage Treatment Plant through a 2.8-mile, nominal 12 inch diameter, high density polyurethane pipe.

### 4.3 Slurry Pipeline Design Characteristics

The coarse coal slurry pipeline will be called on to transport a range of coals under varying conditions. The pipeline will be designed to operate under a fairly wide range of conditions, but at the same time has fairly strict limits for its operation. In selecting the pipe diameter, the main variables are concentration and velocity (the size consist range is essentially fixed). In addition, the required flow rate of 4,000 t/h was also fixed.

**Concentration Limits** — The upper limit on concentration is set by the capabilities of the storage reclaim unit. The hydraulic reclaim type unit used in the base case is reported to be able to recover at 50% solids by weight on a continuous basis. Since this figure has not yet been proven commercially on coarse coal, a figure of 45% was used as a design basis for the study. On the lower side, a limit of 15% solids by weight was arbitrarily selected. The primary purpose for selecting a lower limit is to size equipment in the dewatering plant.

**Velocity Limits** — In order to transport coarse coal without plugging the pipeline or creating massive concentration waves, which will not be tolerable in the dewatering plant, the flow in the pipeline must be above the deposition velocity. For coarse coal slurries, the deposition velocity increases both with increasing concentration and increasing diameter. Both the Modified Durand method and Hanks and Sloan method were used to predict deposition velocity. In addition, conventional friction loss versus velocity curves were plotted to determine the "hook", i. e., the point at which the pressure drop is a minimum and increases with decreasing velocity, which, of course, is an unstable condition. Calculated deposition velocities varied from 10 to 11.5 ft/sec at concentrations of 30 to 50% (for a 28.938 inch I.D. pipe). The pressure drop versus velocity curves, however, tend to look at higher velocities, i. e., 13 to 14 ft/sec. For purposes of the study a design velocity in excess of 14 ft/sec was set as a criterion.

Since abrasion and attrition are a function of velocity to the second or third power, there is also an incentive to keep the velocity as low as possible. Therefore, the diameter selection becomes fairly straightforward. The following table illustrates this.

**Flow Velocities**
**(At 45% Concentration by Weight)**

| Pipe O.D. (inch) | Wall Thickness (inch) | Lining Thickness (inch) | Pipe I.D. (inch) | Velocity<br>Design (4,400 t/h) | <br>Expected (4,000 t/h) |
|---|---|---|---|---|---|
| 34 | 0.531 | 1.0 | 30.938 | 13.9 | 12.7 |
| 32 | 0.531 | 1.0 | 28.938 | 15.9 | 14.5 |
| 30 | 0.500 | 1.0 | 27.000 | 18.3 | 16.7 |

As shown, the 34 inch O.D. pipe results in velocities close to or below the anticipated deposition velocity. This diameter was rejected. Velocities in the 32 inch line are above, but still fairly close to the estimated deposition velocity. The 30 inch line produces velocities which are comfortably above deposition but will result in added wear and particle attrition. For purposes of the study then, the 32 inch line was selected. Before detailed design, additional work will be done to confirm deposition velocities and to investigate stability and concentration waves prior to final selection of diameter, velocity and concentration. At the design velocity of 15.9 ft/sec and the design concentration of 45% solids by weight, the discharge required is 775 psig. The design gradient at 15.9 ft/sec is 105 psi/mile or 211 ft/mile.

**Abrasion/Attrition** — Due to the high velocities and the coarseness of the coal particles, abrasion and attrition are expected in the pipeline. Basically, a great deal of energy (i. e. horsepower) is being put into the slurry to transport it; part of that energy will be consumed in the impact of the particles against the pipe wall and against each other. To mitigate the pipe wear aspects, it is necessary to line the pipe with an appropriate lining. This is complicated by the fact that good long term commercial scale data do not exist for wear rates of coarse coal slurries or for lives of various linings. Therefore it has been necessary to extrapolate from limited existing data. Data from Russia, reported by Turchaninov, toroid wheel tests, plus other PSI in-house data were used to predict pipeline wear. It appears that wear rates and attrition will be much higher for uncleaned than for cleaned coal. For the purpose of this analysis, it was assumed that for cleaned coal transported at the annual rate of 20 mill. t, the wear rate in bare carbon steel would be about 0.3 inch/year. This, of course, is not tolerable for a 30 year life project. Various lining materials were considered, including basalt, polyurethane and ceramic. Polyurethane was selected on the basis of existing commercial experience and data indicating the life with polyurethane lining should be about ten times that of bare steel. This results in a required wall thickness of polyurethane of 0.9 inch. A polyurethane thickness of 1 inch was used for costing purposes. This is a significant expense, and additional engineering and test work are needed to optimize this aspect of the project.

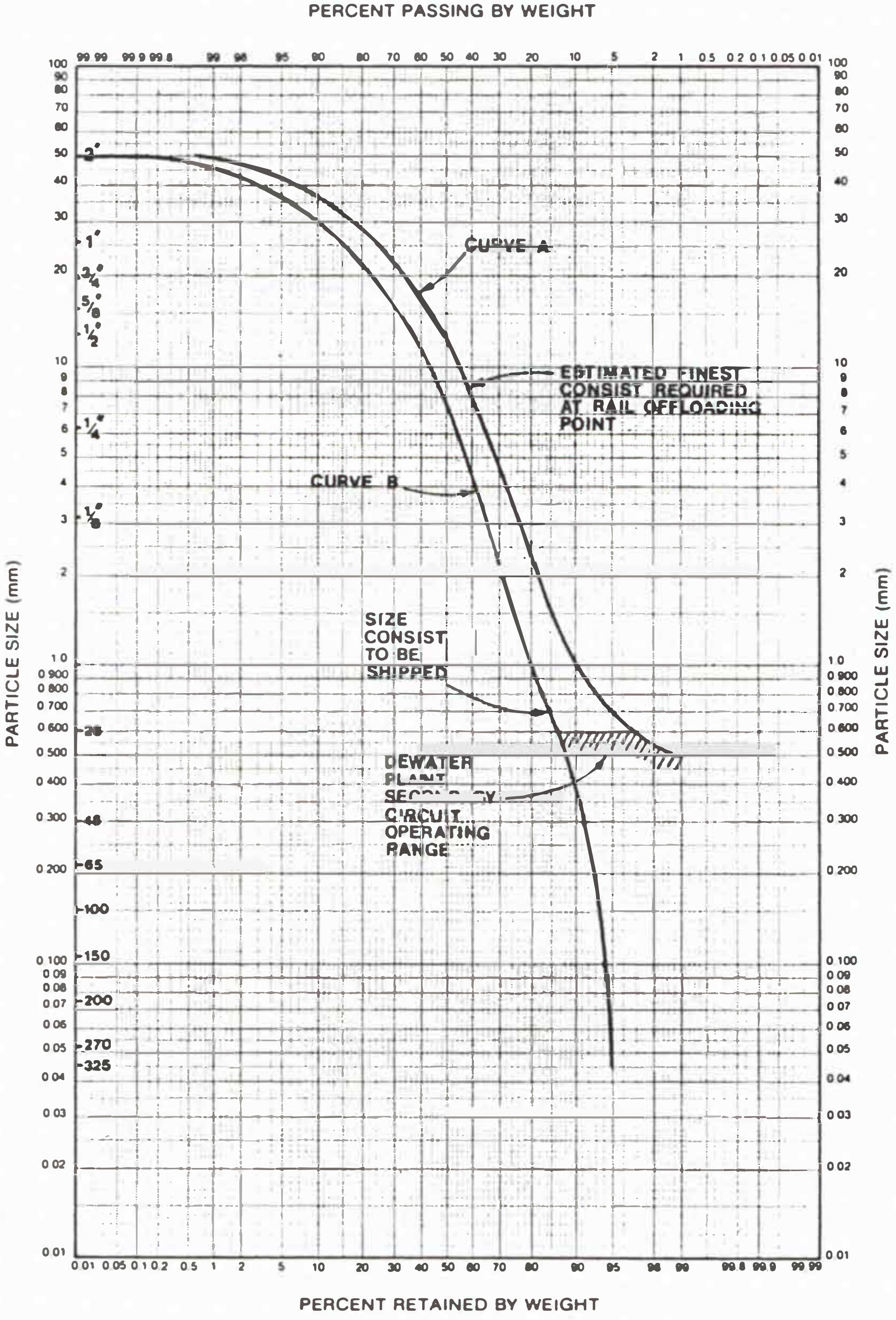
A corollary of wear, or abrasion, is attrition. Some of the particles will attrite or be reduced in size as a result of impacts with the pipe wall or with themselves. Data are sparse in this area and show wide scatter.

Fig. 4 shows the estimated size consist of the rail coal received and the final estimated size consist at shipside, considering the equipment that the coal will normally pass through, as well as the pipeline degradation component. The total degradation is a best estimate, given the hypothetical coal used for the study. Additional test work will be required before final design.

Major sources of coal degradation, beginning at rail shed and ending at the ship, will be as follows:

- Rail dumper
- Conveyor transfers (2)
- Silo fill
- Rotary feeder
- Pipe to pond (1,000 ft)
- Reclaim unit (one centrifugal pump)
- Pipe to pump station (1,000 ft)
- Lock-hopper pump station
- Pipeline (7 miles)
- Dewatering plant (vibratory and screen bowl centrifuges)
- Ship loadout system

Fig. 4: Staten Island Coal Slurry Pipeline — size consists



Curve A can be used for producing an estimated specification size consist for rail-delivered coal to Arlington. The coal received is assumed to have been cleaned prior to delivery to the slurry system.

**Freezing** — The pipeline will be buried to a minimum depth of three feet. This is below the maximum anticipated freezing depth of 28 inches. In addition, while the pipeline is operating, the heat of friction will also reduce the freezing potential. The only potential problem is freezing in the spans over the crossroads on the expressway. This, of course, is only a problem if the system is shut down. A simple way to avoid freezing in these sections is to operate the system for a few minutes to move the water in the line on to a different location.

**Emergency Shutdown and Restart** — The slurry pipeline is not designed to be routinely stopped and started with coal in the pipeline. However, at times during the operation of the pipeline, shutdown with coal in the pipeline will be necessary. Several anticipated events will require pipeline shutdown:

- Power failure at Arlington
- Power failure at Stapleton
- Process upset in the primary circuit at Stapleton
- Surge silos full and ship loader fails.

Precautions have been taken in the design to limit the pipeline slopes, which should allow the solids to settle fairly rapidly to the pipe floor. Slopes in the median of the Staten Island Expressway are below 5%. No unnecessary vertical pipes, which could cause plugging problems, will be installed in the ultimate design.

Restart of the pipeline will be made using water. The mainline pump station will be started slowly on water to prevent excess horsepower draw as the solids are suspended. The line flow will be progressively increased until the normal pipeline flow is achieved.

Should a plug occur at some point along the pipeline, it is intended to use a crossover valving concept to clear sections of the pipeline back to Arlington using the water pipeline. Crossovers, or tie-ins, between the coal line and the return water line will be located at approximately $1\,^{1}/_{2}$ mile intervals. The crossover will consist of a 16 inch pipe section and a 16 inch valve that is normally closed. The slurry line and return water line will also contain valves adjacent to the crossover that are normally open. All valves will be contained in a concrete vault. By opening selected crossover valves and closing selected mainline valves, the water return line can be used in the unlikely event of a plug. Work would progress down the line from Arlington until the line is cleared to the crossover nearest the plug. At that point, water pressure from the Arlington or Stapleton pumps would be applied to the plug and attempts made to remove it hydraulically.

### 4.4 Dewatering Facility

At the Stapleton waterfront, the only operations are dewatering and shiploading. Again, the scenic vistas from the Stapleton waterfront and the sensitivity of the nearby community to noise and dust have been carefully considered. The dewatering will take place inside a fairly large industrial building which will be located in the southern portion of the site, close to existing mass transit repair yards. Approximately one acre will be needed for the dewatering facility.

From the dewatering building, the coal will travel by covered conveyor belts to a shiploader and then into the hold of the collier. A finger pier configuration will be used for shiploading.

See Fig. 5 for the slurry pipeline system schematic.

### 4.5 Oil Import Terminal

Simultaneous with the coal slurry system plans, the Port Authority of New York and New Jersey is planning an oil import terminal for the Stapleton waterfront. This terminal would pump oil through two pipes along the identical right-of-way from Stapleton, across Staten Island, into New Jersey to the Exxon and Chevron refineries. This terminal requires a channel depth of 68 ft to accommodate Exxon's and Chevron's fleet of 260,000 DWT VLCCs. The ability to dredge New York Harbor is enhanced by the joint development of an oil import terminal and a coal export terminal at the Stapleton waterfront. Some economies of scale can be achieved by construction of both pipelines across Staten Island, user fees for the dredging can be reduced, and reconstruction of the Stapleton waterfront will be enhanced through the revenues these terminals will generate. The oil terminal, which consists of only a pier and a small pumphouse, will have a minimum impact on Stapleton's magnificent views.

## 5. Summary and Plans

What has been presented thus far represents nearly two years' work by the City's Department of Ports and Terminals and its consultants. There are many issues that must be resolved before the terminal can be built. Issues such as rail rates, dredging and user fees, environmental permits, financing, technical development work, etc., must be addressed. Two firms were retained to assist the Department of Ports and Terminals in the second stage of the project from a technical standpoint. The firm of Tippetts-Abbett-McCarthy-Stratton (TAMS) has studied the rail yard and the waterfront structures. Pipeline Systems, Inc., has analyzed and prepared a conceptual design of the slurry system. TAMS has also been retained to perform a preliminary environmental assessment of the project. The Port Authority has retained PRC Harris to prepare a feasibility study of the oil import terminal. Both studies were completed during the summer of 1982. In addition, the City has retained two urban design and landscape architect firms to help factor in, from the start, the public access and necessary buffers. The firms selected to work on this aspect of the project are Buckhurst Fish Hutton Katz and Quennell Rothschild Associates. The City has also retained its own financial and legal consultants to assist in the next phase of the project development.

Letters of Interest have been received from potential developers and requests for formal proposals were due October 8, 1982. The City plans to make its choice of developer immediately and enter into negotiations immediately to meet the scheduled opening in 1986.

We would like to conclude with a few remarks about the Department of Ports and Terminals and the role it plays within City government and the Port of New York. Since it is a City agency, it has a number of missions. First, is the development of the port facilities under the jurisdiction of the City. Second, it is concerned with the development of the City's economy. Third, the Department is the lead

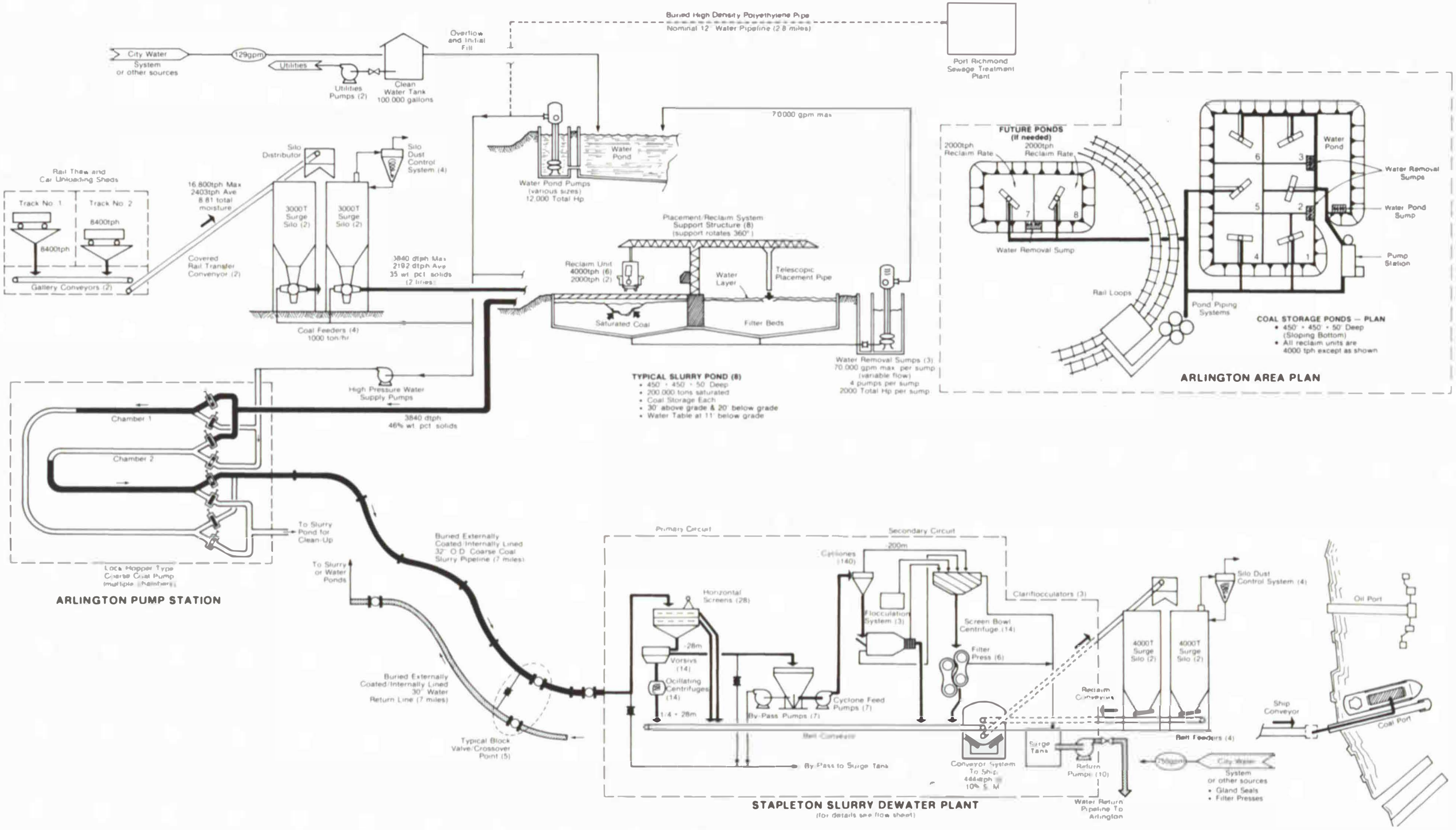


Fig. 5: System schematic, Staten Island Coal Export Terminal

agency within City government responsible for the redevelopment of waterfront property no longer useful for maritime commerce and trade. The Department brings a multi-faceted approach to port planning, an approach perhaps unique among port agencies in the United States.

With the coal terminal project in Staten Island, the Department will be able to bring about an environmentally sound and economically viable coal terminal, thereby improving the economy of the port. This terminal will also improve the financial situation of Conrail and allow the City to have continued and improved access to rail freight. This project can also generate the revenue flow necessary to improve a mile-long section of the City's waterfront, a section long characterized by decay. Since the project will be financed by the private sector, the amount of capital budget money from the City of New York is minimized, thus allowing it to concentrate on rebuilding its deteriorating infrastructure.

This project has generated more excitement within the City government than any in memory. The project is a unique solution to development of a major industrial facility in a densely populated urban area. We believe it can work and we are proud of what has been accomplished to date.

## References

[1] "Coal — Bridge of the Future", Massachusetts Institute of Technology, page 244, 1980.

[2] "Potential Role of Appalachian Producers in the Steam Coal Export Market", ICF, Incorporated, page 9.

[3] "Economic Comparison/Gearless Bulk Carrier", Port Authority of New York and New Jersey, August, 1981.

[4] "Engineering and Economic Study for a Coal Transshipment Facility — Phase I", ORBA Corporation, prepared for the Port Authority of New York and New Jersey, July, 1981.

## Acknowledgements

I would like to thank the managers of the proposed coal export terminal at Ports and Terminals and the Department's consultants, Tippetts-Abbett-McCarthy-Stratton, Pipeline Systems, Inc., Buckhurst Fish Hutton Katz and Quennell Rothschild Associates.